Kentucky Geological Survey

CHARLES J. NORWOOD, Director

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PRELIMINARY REPORT ON

The Economic Geology of the Hartford Quadrangle.

By JAMES H. GARDNER.

AND ON

THE SOILS OF THE SAME QUADRANGLE

By S. C. JONES.

FIELD WORK DONE IN 1910

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CONTENTS.

I. ECONOMIC GEOLOGY OF THE QUADRANGLE. Page

General Statement 1
Topography and Culture 2
Stratigraphy 4
General Section of the Strata 5
Geologic Structure 6
Mineral Resources 8
General Statement 8
The Coals 10
Iron Ores 17
Clay Deposits 18
Cement Materials 19
Oil and Gas 20

II. SOILS OF THE QUADRANGLE.

General Statement 26
Phases of Topography 26
General Drainage 26
Soil Types 27
Yellow Silt Loam (Hilly) 27
Yellow Silt Loam (Undulating) 30
Yellowish Gray Silt Loam (Bottom) 31
Gray Silt Loam (River Bottom) 31
Yellow Clay Loam (River Bottom) 32

Page Maps.

Northwest Quarter of the Quadrangle 9
Northeast Quarter of the Quadrangle 11
Southwest Quarter of the Quadrangle 13
Southeast Quarter of the Quadrangle 15

LETTER OF TRANSMITTAL.

His Excellency, AUGUSTUS E. WILSON,
Governor of Kentucky.

Sir: I have the honor to transmit herewith a preliminary report on the economic geology of the Hartford Quadrangle by James H. Gardner, together with an account of the soils of the Quadrangle by S. C. Jones. While it is to be regretted that the report on the economic resources is not final in character, its usefulness will be appreciated by all who are interested in the development of the region covered by it. The page-maps showing the areas of "No. 9" coal, and the discussion of structure with reference to the possible occurrence of petroleum and natural gas, are of much practical value to prospectors.

Very respectfully,

C. J. NORWOOD,
Director, State Geological Survey.

August 1, 1911.

LETTER OF SUBMITTAL.

PROF. CHARLES J. NORWOOD,

Director, Kentucky State Geological Survey,

Lexington. Ky.

Sir: I have the honor to submit to you a Preliminary Report on the Economic Geology of the Hartford Quadrangle. Four page-maps, prepared by myself and labelled Plates 1, 2, 3 and 4, accompany it for the purpose of showing outcrops and other locations.

Very respectfully,

JAMES H. GARDNER,

Assistant Geologist.

PRELIMINARY REPORT ON THE ECONOMIC GEOLOGY OF THE HARTFORD QUADRANGLE.

JAMES H. GARDNER.

The Hartford Quadrangle is located almost entirely in Ohio County near the eastern border of the Western Kentucky Coalfield. The Illinois Central Railroad crosses it in an approximate north-east south-west direction, the town of Beaverdam on that road being not far north of the center. In this report, the area has been divided in to four equal divisions and page-maps prepared of each quarter. The topographic sheet of this quadrangle, made in co-operation with the U. S. Geological Survey, has served as a base in the preparation of these maps. A sufficient amount of the drainage and culture is shown to enable a proper discussion of the geology and to make locations definite.

This report is prepared especially to meet the demands of the practical mining man. It is not so complete as may be desired nor does the writer presume it is without errors. The best efforts have been put to use, however, to furnish accurate data and to give herein such information as will, at present, fill the greatest demand. A fuller discussion of the mineral resources, general geology, and scientific deductions is reserved for a final bulletin covering this and a larger area.

In writing this report, reference has been freely made to previous reports relating to the same general region. Of these, the most important is one printed in 1880 entitled "A General Account of the Geology of a Part of Ohio County,"* by Charles J. Norwood, now Director of the

*Kentucky Geological Survey, New Series, Vol. 5, Pt. 5, pp. 79–123. Reprinted in 1884 in Vol. D. pp. 133–177.

a Kentucky Geological Survey. Director Norwood has a personal knowledge of the coals and their development, outside of what he has published, and the writer acknowledges his indebtedness to him for such assistance as he has given. The writer wishes also to express his indebtedness to Messrs. W. B. Paynter and D. W. Smith who assisted by instrument work in the field; to Messrs. John B. Wilson and Mawarth W. Barnard of Hartford, Ky., Mr. Everett Taylor of Beaverdam, Ky., and Mr. Simon Jones, Mine Foreman for the Central Coal and Iron Company, at McHenry, Ky.

TOPOGRAPHY AND CULTURE.

The topography of the Hartford Quadrangle is of comparatively low relief and has been produced essentially by normal stream erosion on rocks of variable hardness; to a less extent the topography has been influenced by faults and folds. The elevation above tide varies from 400 feet along the drainage levels to 700 feet on the highest points, and will average about 500 feet. The hills have, as a rule, gentle slopes from the valleys, exceptions to this statement being confined locally to the steep bluffs along Rough river north of Hartford and along Green river southwest of Cromwell and in the vicinity of Paradise and Rockport. The valleys are broad and the streams have slight gradients so that occasionally, in times of heavy, continuous rains, they overflow their banks and spread over large areas on either side.

The close network of wagon roads that covers the whole quadrangle testifies to the practicability of overcoming all grades for purposes of traffic. It is not difficult to select routes for railroad construction to any district in the field. There are two lines of standard gauge railway crossing the quadrangle: the Illinois Central Railroad and the Madisonville, Hartford and Eastern Railroad. Green River affords navigation throughout the year as far up as the mouth

of Nolin River, in Edmonson county above Brownsville, and up Baren River to Bowling Green on the main line of the Louisville and Nashville Railroad south of Louisville; the river carries freight chiefly down stream to Evansville, on the Ohio.

Coal mining and farming are the chief pursuits in this region. Coal bed No. 9 is being extensively mined at Williams, New Render, Taylor Mines, Simmons, Echols and Rockport. Country mines are common. Farming is confined more or less to the bottom lands along the streams where the soil is of alluvial origin. The hill country often contains very thin, sandy soils which are adapted to only a limited number of agricultural products. Woodland growth covers a considerable percentage of the upland country and still furnishes a limited supply of lumber, railroad ties, etc., but has been heavily drawn on in past years. There is, however, an abundant supply of timber suitable for mine props, and demands of this nature will likely be met for some time to come. Now and then one finds a small acreage of timber land which has been preserved by the owners and still shows a bit of the noble forest that once covered the richer lands in this section of Kentucky.

STRATIGRAPHIC GEOLOGY.

The rocks of the Hartford Quadrangle lie entirely in the Carboniferous System and chiefly in the Pennsylvanian series. The Mississippian series is represented by a small area of the Chester group along Rough river on the north boundary of the quadrangle, but with this exception the rocks are in the Pennsylvanian or what is commonly called the Coal Measures. The various subdivisions of the Chester and the Coal Measures have not as yet been definitely worked out and mapped in this region but important information is being gathered with this end in view. The lithologic character and the palaeontology of the strata are being studied by different geologists in various parts of the Western Kentucky Coalfield in order that a general classification may be made of the entire field. The writer has procured sufficient data on the stratigraphy of the Hartford Quadrangle to form a good working basis for arriving at a future classification. It is necessary in this brief report to set aside to a large extent points of purely scientific interest and confine the discussion to facts of directly economic bearing.

On a suceeeding page is given a generalized section of the quadrangle as best the writer knows it. This section is subject to correction in a future publication, after addional field work is completed. It does not vary notably from the section published by Director Norwood in his report on the geology of a part of Ohio county.*

Most of the members of the section are variable in both thickness and character in different districts. No two sections by different writers, or even by the same writer, would absolutely agree when made up from notes taken in different localities; consequently the character and thickness of each stratum as given in the general section can only be an average.

*Kentucky Geological Survey, New Series, Vol. 5, Pt. 5, pp. 79–123.
Reprint in Vol. D, Western Kentucky Coalfield, pp. 133–177.

General Stratigraphic Section.

	Ft.	In.
Sandstone, massive, coarse-grained, brown	40	..
Shale, sandy	3	..
Coal, Elmwood	1	..
Shale, carbonaceous	5	..
Coal (probably No. 13 of Hutchinson)	2–4	..
Sandstone and shale, locally massive sandstone	23	..
Coal (probably upper member of No. 12) local	..	10
Shale, gray	5	..
Coal (probably lower member of No. 12)	1	8
Shale	10	..
Limestone, hard, dense, gray	2	..
Coal, No. 11	0–7	..
Underclay, locally absent	2	..
Shale	21	..
Sandstone	4	..
Shale	15	..
Coal, No. 10	..	10
Shale and sandstone	15	..
Sandstone	25	..
Shale containing small limonite concretions	25	..
Shale, hard, dark, bituminous (called "Black slate")	2	..
Coal, No. 9	4	4
Underclay	3	..
Shale containing ferro-calcareous concretions and local beds of soft sandstone	50	..
Shale, bituminous	3	..
Coal, Goshen	1	4
Shale and some sandstone	15	..
Limestone, dense, gray, wetathers yellowish	2	..
Sandstone and shale	10	..
Shale, bituminous, dark	1	6
Coal, Schultztown	1	3
Underclay, plastic, gray	3	..
Sandstone, soft, gray, weathers brown	32	..
Shale, bituminous	1	6
Coal, Beaverdam	1	..
Underclay, plastic, gray	3	..
Limestone, dense, gray, often nodular or cherty	2	..
Sandstone and shale, local coal streak	50	..
Sandstone, massive, gray	5	..
Shale, gray, local coal streak	15	..
Shale	2	..
Shale, bituminous	1	6
Coal, Hartford	1	6
Sandstone and shale	75	..
Shale	5	..
Limestone, hard, bluish	1	6
Shale, limestone bed locally present	3	10
Coal, Millsite	..	8
Underclay, plastic, gray	2	6

GENERAL SECTION—Continued.	Ft.	In.
Shale and some sandstone	8	..
Chert, Norwood's "Fusulina chert"	..	6
Shale and sandstone	20	..
COAL, BEDA	1	5
Sandstone, massive, soft, gray, micaceous	20	..
Shale, locally sandstone	60	..
Shale, bituminous	3	10
COAL, NORWOOD'S "ELM LICK COAL"	4	6
Underclay, variable	1	..
Shale, gray, sandy	50	..
COAL, HAMLIN	1	8
Shale, gray, sandy	25	..
Sandstone, massive, brown, (absent in north part)	50	..
Shale, with thin sandstone and limonite	30	..
Limestone with alternating beds of shale (Chester)	70	..

STRUCTURE.

The writer can not attempt here to fully describe the structure of the rocks of the Hartford Quadrangle; he can only briefly outline the subject in order that those interested in the exploitation of the mineral resources may somewhat understand the conditions with which they have to deal.

There are always two view points in describing structure as well as in describing stratigraphy; one is a view looking broadly and generally over the field under discussion, whereas the other is a view of local conditions in special districts. It is the former with which men have to deal in laying out the general location of property for development and it is the latter, or local conditions, with which the practical mining man has to deal in his operations.

Generally speaking, the structure in the region of this report is not such as to present difficult problems in relation to mining. There are numerous small faults, or dislocations of strata, and many minor folds at various points over the quadrangle, but in most cases these may be overcome in the respective districts as practical mining demands.

The Hartford Quadrangle is near the eastern rim of the Western Coalfield and the rocks should normally have a gentle dip westward toward the basin. However, speaking very generally, they dip southwestward as a result of the influence of the Rough Creek Uplift. This disturbance crosses the south part of the Whitesville Quadrangle, a short distance beyond the north boundary of the Hartford Quadrangle. It takes the form of an exensive zone of faulting, with folds on the south or upthrow side, from the vicinity of Sulphur Springs southwestward to Lick branch then following roughly the courses of Clear Run and Barnetts creek. It has been mapped by the writer in connection with his work on the south side of the Whitesville Quadrangle. This work is reserved for future extension in connection with the geology of that quadrangle and a final bulletin on the general district. The Rough Creek Uplift in this region runs roughly in an east-west direction though its course is variable. It is an extensive structure and continues westward into Illinois. Director Norwood and others have described it at different points; it is variable in character along its extension and is apparently at some places a fold or series of folds while at others it is a fault or series of faults; at some points it appears to be a combination of the two main characters, the folding and faulting having very probably taken place as a result of the same pressure.

The rocks along the north side of the Hartford Quadrangle, ruling out minor structures, dip southward away from the uplift. The effect of this southward dip on rocks having normally a dip westward into the basin, has produced a component dip southwestward. The result of erosion on rocks dipping southwest tends to produce an outcrop line roughly parallel to the strike, which in this case is about northwest-southeast. A glance at the outcrop of No. 9 coal from the northwest quarter of the quadrangle southeast to where it is interrupted by the drainage of Green river, shows the general strike of the rocks. If one have before him a topographic sheet of the quadrangle he is able to note this strike line from the topography. This southwestward dip of No. 9 coal

has caused it to recede by erosion to the southwest quarter of the quadrangle; it rises to the northeast and the plane of its extension over-rides the northeast quarter of the quadrangle where lower coals are found. In the latter region the principal coal is the one previously called by Director Norwood the Elm Lick Coal.

In the northwest quarter of the quadrangle a synclinal structure is developed from the mouth of Muddy creek westward by the mouth of Walton creek and thence into the Central City Quadrangle where it has been noted by Mr. Hutchinson.*

The rocks on either side of the axis of this syncline rise on a slope of about 4 degrees, and a low corresponding anticline exists on the south, the axis crossing Big Run at Centertown. On the south of this is another shallow syncline and a corresponding low anticline the axis of which crosses the west fork of Lewis creek, two and a half miles south of Centertown. These folds run parallel to the main Rough Creek Uplift and are evidently a result of lateral pressure from the forces that produced the main disturbance. There are several such folds along the north side of the quadrangle, such as the synclinal ridge crossed by the Owensboro road one mile and three quarters from Hartford, and the corresponding anticline one half mile farther on.

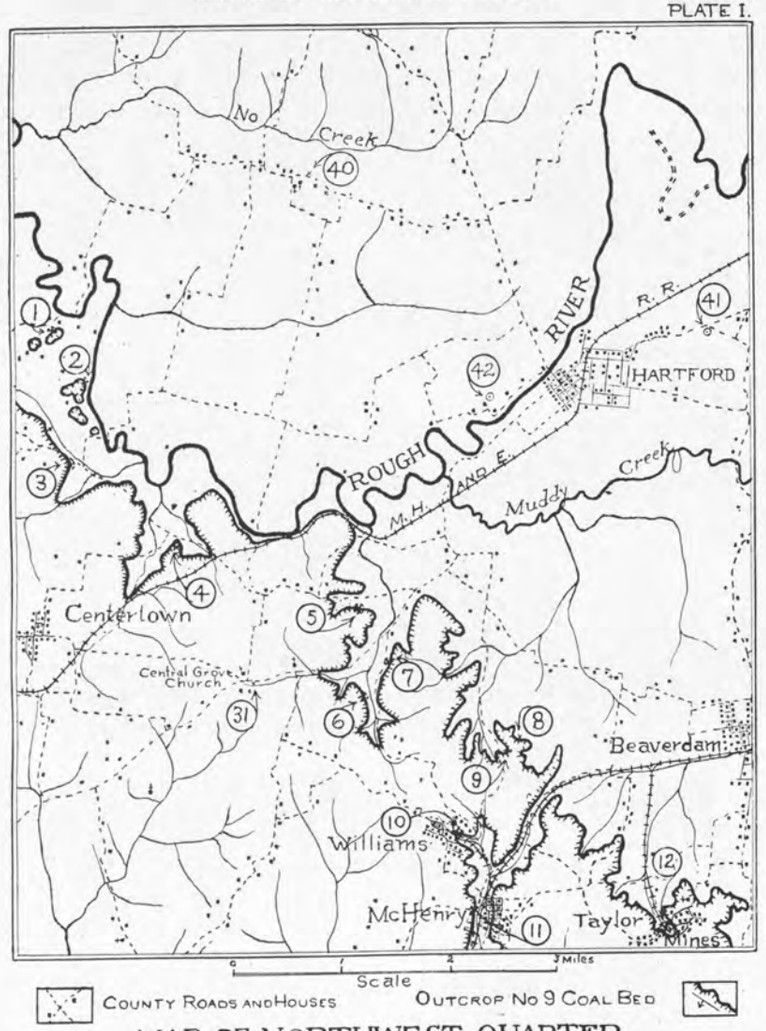
The small areas of No. 9 coal in the High View Hills on Green River below Cromwell are the result of erosion on rocks dipping westward into the basin; in this vicinity Slaty creek has cut its way entirely through the beds containing No. 9 coal, leaving small outliers in the hills to the east.

MINERAL RESOURCES.

While a full description of the mineral resources of the region under discussion must await a final bulletin covering a larger area, such information is given below as will be most in demand at present.

*Hutchinson, F. M. Coals of the Central City and Madisonville Quadrangles. Rept. of Progress, Ky., Geol. Survey, 1910 p. 57.

PLATE I.



MAP OF NORTHWEST QUARTER
HARTFORD QUADRANGLE

Location No. 1, thickness 4 ft. 2 in.
Location No. 2, thickness 4 ft. 4 in.
Location No. 3, thickness 4 ft. 4 in.
Location No. 4, thickness 4 ft. 4 in.
Location No. 5, thickness 4 ft.
Location No. 6, thickness 4 ft. 4 in.
Location No. 7, thickness 3 ft. 7 in.
Location No. 8, thickness 4 ft. 6 in.
Location No. 9, thickness 4 ft. 6 in.
Location No. 10, thickness 4 ft. 4 in.
Location No. 11, thickness 4 ft. 4 in.
Location No. 12, thickness 4 ft. 10 in.

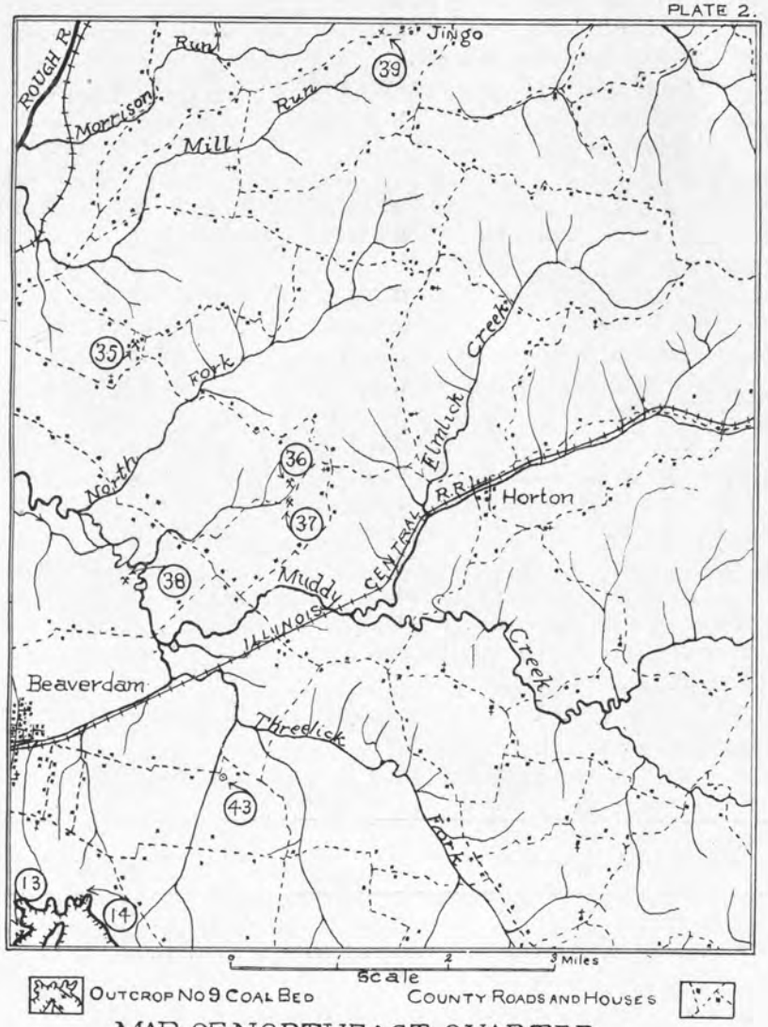
The Coals

Among the known resources of the Hartford Quadrangle, coal holds first rank. The most important coal bed is No. 9, the outcrop of which is shown by heavy black lines on the accompanying page-maps. For the horizon of No. 9 coal relative to other beds, see the general stratigraphic section.

No. 9 coal is exceptionally uniform and persistent in thickness over a large portion of the Western Kentucky Coalfield. In this quadrangle, it averages 4 feet 4 inches in thickness and does not vary to any great degree from point to point in either thickness or quality. It has invariably a good, black-shale roof and a variable underclay. The quality of this coal for steam and fuel gives it an extensive market. Prominent mines in No. 9 coal are in operation along the line of the Illinois Central Railroad at Taylor Mines (slope) and Williams (slope) by the Taylor Coal Company; at McHenry (slope), New Render (slope), and Echols (shaft) by the Central Coal and Iron Company; at Simmons (shaft) by the Broadway Coal Company and at Rockport (shaft) by the Rockport Coal Company. There are numerous small mines along the outcrop, away from the railroad, which supply coal to the local trade. The coal is hard, bright, and ships well. It is free of shale, due to the absence of partings and the clean nature of the roof. It runs too high in sulphur for the purpose of making coke to be used in the iron industry except after washing. When carried through a good washing process, it produces a good firm coke carrying about 1 per eent sulphur.

No. 9 coal lies well for mining and is rarely as deep as 150 feet below the surface. The deepest shaft in the district is that of the Rockport Coal Company which is 117 feet deep. The average depth of this coal in the Hartford quadrangle is probably about 70 feet The numbers below each map refer to corresponding numbered locations on the maps where the writer obtained measurements of No. 9 coal as given for each location.

PLATE 2.



MAP OF NORTHEAST QUARTER
HARTFORD QUADRANGLE

Location No. 13, thickness 5 ft. Location No. 14, thickness 5 ft. 8 in. (latter thickness unusual).

The series of measurements given with the maps is very exceptional as regards uniformity in thickness of any coal bed. In every case the bed has a black shale roof and is free of partings.

Available analyses seem to indicate that the average composition of No. 9 coal in this region will run about as follows in proximate analysis: Moisture, 3.50; volatile combustible matter, 35.00; fixed carbon, 51.00; ash, 7.00; sulphur, 3.50. The high percentage of sulphur in this coal is due to seams of iron pyrites which usually occur near the top or bottom of the bed, and which may be separated from the coal by washing processes.

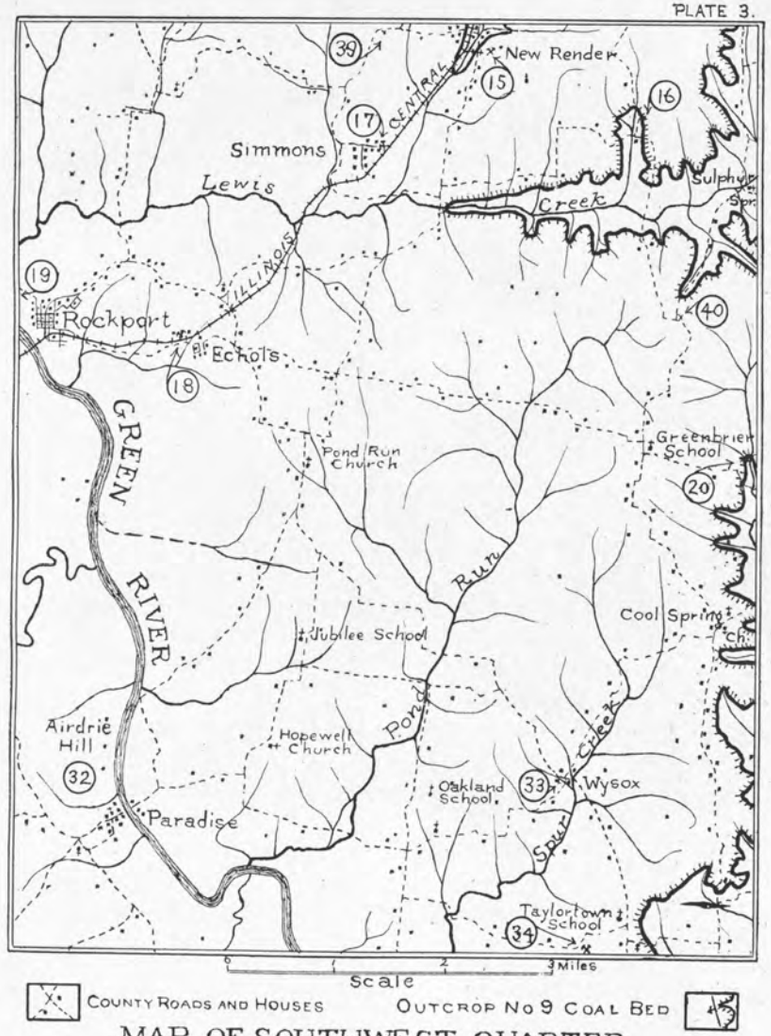
There are no large mines in this quadrangle in any coal bed other than No. 9. There are local or country mines in two other beds, namely in bed No. 11 and the Elm Lick bed.

No. 11 coal is very slightly mined in this region but it is considered an important reserve supply in certain parts. It lies higher in the hills than No. 9 and is consequently more limited in acreage at a great many places. It has been entirely eroded over a considerable area which is still underlain by No. 9. There are very few openings in No. 11 coal bed. At location No. 24 on the map of the southwest quarter of the quadrangle, Plate 3, coal No. 11 is mined locally by H. W. Taylor. The bed is here made up of the following section:—

Section of No. 11 Coal Bed at H. W. Taylor Mine.

	Ft.	In.
Roof limestone, locally shale.		
Coal	1	10
Clay shale	0	¼
Coal	2	3
Clay shale	0	2
Coal	2	10
Underclay.		
Thickness of bed	7	1¼
Total coal	6	11

PLATE 3.



MAP OF SOUTHWEST QUARTER HARTFORD QUADRANGLE

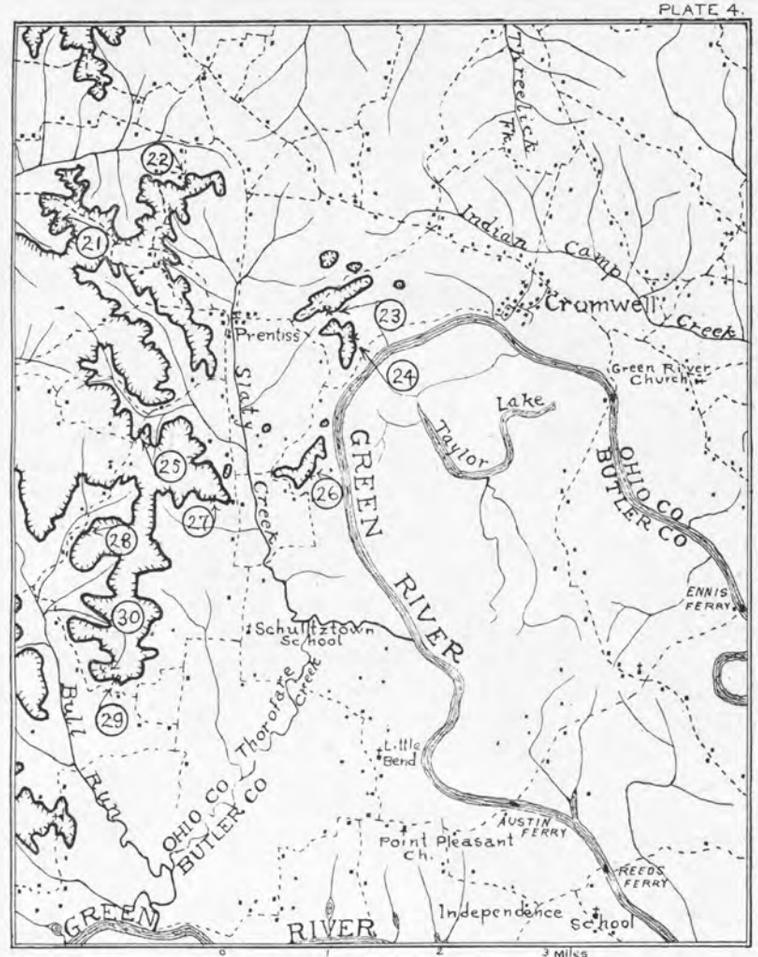
Location No. 15, thickness 4 ft. 6 in.
Location No. 16, thickness 4 ft. 4 in.
Location No. 17, thickness 4 ft. 4 in.
Location No. 18, thickness 4 ft. 4 in.
Location No. 19, thickness 4 ft. 5 in.
Location No. 20, thickness 4 ft. 2 in.

In the vicinity of Paradise and Airdrie, Location No. 32, Plate 3, this bed is reported 6 feet thick. Coal bed No. 11 in this quadrangle is not regular in thickness. Often a bed of limestone rests directly on the coal and at other places it cuts the coal out, so to speak. A limestone roof is an unnatural condition and it is highly probable that this particular limestone bed is unconformable; in other words, that an interval of erosion, probably marine, existed just after the deposition of the coal and previous to, or during, the deposition of the limestone, so that, in certain districts, the coal was carried away before the limestone was laid down. When a thin bed of shale exists between the coal and the limestone, the bed is more likely to show its orginal thickness. This same condition is often met with where a massive sandstone lies directly on a coal bed.

At location No. 30, Plate 4, about five and a half miles southwest of Cromwell, No. 11 coal has been opened and is reported 6 feet thick. The old opening was entirely filled so that the writer could not see the bed at this point. At location No. 33, Plate 3, near Wysox, the bed varies from 5 to 6 feet in thickness. No. 11 coal in nearly every case contains two clay-shale partings as typically shown in the section obtained at the H. W. Taylor Mine. The coal is of good quality but, like No. 9, is a little too high in sulphur to make good coke for use in the iron industry except after washing. Judging from available analyses, the average composition of No. 11 coal in this region of the State is about as follows in proximate analysis: Moisture, 3.00; volatile combustible matter, 35.00; fixed carbon, 53.00; ash, 6.00; sulphur, 3.00.

Along the west side of the Hartford Quadrangle, between Rough river and Lewis creek, No. 11 coal is rarely of workable thickness. At location No. 31, Plate 1, near Central Grove Church, it shows a thickness of 31 inches with a 1-inch parting 6 inches from the top. At other points it is a thinner coal but always beneath the regular limestone roof, when present at all. In this district there is a higher bed, however, which is commonly referred to in the neighborhood as No. 11 coal bed; it is of notable

PLATE 4.



MAP OF SOUTHEAST QUARTER
HARTFORD QUADRANGLE

Location No. 21, thickness 4 ft. 6 in.
Location No. 22, thickness 4 ft. 4 in.
Location No. 23, thickness 4 ft. 5 in.
Location No. 24, thickness 4 ft. 4 in.
Location No. 25, thickness 4 ft.
Location No. 26, thickness 4 ft. 6 in.
Location No. 27, thickness 4 ft. 4 in.
Location No. 28, thickness 4 ft.
Location No. 29, thickness 4 ft. 3 in.

thickness at places. It is above No. 12 horizon and is very probably coal bed No. 13 as numbered by Mr. Hutchinson in the Central City Quadrangle on the west.

At location No. 39, Plate 3, on a hill-side one mile southwest of McHenry and one mile and a half north of Simmons, this latter coal shows in prominent outcrop along the roadside; No. 12, No. 11 and No. 10 coal beds, all too thin to work, show farther down the same hill. This coal bed is very probably the one exposed in natural outcrop at location No. 40, Plate 3, about three miles south of Taylor Mines. No accurate measurements have as yet been made on it in this region by the writer but judging from the appearance of the weathered outcrop, it runs as much as 4 feet in certain districts.

The Elm Lick coal bed is mined to supply the local, country trade at several points in the northeast quarter of the quadrangle. The Tyro (No. 35), Tinsley (No. 36), and Howard (No. 37) mines between Horton and Hartford, are on this bed. Also the John Chinn Mine (No. 38) 2 miles northeast of Beaverdam, Plate 2.

The Elm Lick bed furnishes a good grade of fuel and will some time be extensively mined. So far as known, there have been no tests made of its coking qualities but the writer hopes to have such tests for use in a future publication.

The coal of the Elm Lick bed is in two layers separated by a thin layer of clay-shale or possibly fire-clay. The following section of the bed at the Tyro Mine, location No. 35, Plate 2, presents a good idea of the arrangement of the bed:

Section of Elm Lick Coal Bed at the Tyro Mine.

	Ft.	In.
Clay-shale, dark	3	10
Coal	0	10
Clay-shale, gray	0	5½
Coal	2	10½
Underclay.		
Thickness of bed	4	2½
Total coal	3	8½

The coal above the parting in the Elm Lick bed is of a blocky nature and rather soft, while that below the parting is thinly laminated and much harder.

The following sections in the northeast quarter of the quadrangle, Plate 2, are also on the Elm Lick bed: Location No. 36, Henry Tinsley Mine; thickness, 4 ft. 4½ in., with 5 inches of gray clay 2 ft. from the bottom. Location No. 37, B. H. Howard Mine; same thickness as at location No. 36. Location No. 38, John Chinn Mine; thickness reported 6 ft., with 4 inches of gray clay 18 inches from the top; mine filled with water at writer's visit.

Available analyses indicate that the Elm Lick coal will run about as follows in proximate analysis: Moisture, 5.00; volatile combustible matter, 39.00; fixed carbon, 51.00; ash, 3.00; sulphur, 2.00.

The various other coal beds shown in the stratigraphic section, and named by the writer for purpose of correlation, are ordinarily too thin to be of commercial interest at the present time. They are irregular in thickness, however, and at certain points along their outcrops are thick enough to invite exploitation and will be drawn on when the thicker coals are exhausted.

Iron Ores.

The iron-ore deposits of the Hartford Quadrangle are entirely undeveloped. There are no mines on any of the beds and no fresh openings. The ore is chiefly limonite (hydrous ferric oxide) and at the present time the deposits are of interest only from the view point of supply. At some future date, the demand for iron ore will bring about the development of the limonite deposits of this country and then the ores of the district under discussion will be valuable because of their favorable situation. Transportation by water and rail are near at hand and limestone for fluxing purposes outcrops in the same region.

At one point in the quadrangle, namely at Airdrie on Green river, Plate 3, there is a thin bed of siderite (ferrous carbonate), which rests on No. 12 coal bed. The ore is only about 6 inches thick, but an attempt was made

in 1857 to mine and use it on an extensive scale. Its availability to transportation on the river and its position relative to fuel were inviting factors for its development, but poor management and attempts to use volatile coal raw in the furnace caused the abandonment of the proposition after a brief trial.

The beds of limonite are evidently of the bog type and rather extensive. They vary in thickness from very thin seams to more than five feet. Judging from available analysis, the better grades of limonite ores of this region will average about 40 per cent. metallic iron and less than one quarter per cent. phosphorus.

One quarter mile southwest of Jingo, location No. 39, Plate 2, a bed of limonite outcrops which shows a thickness of 42 inches covered by sandy shale. About one quarter mile east of No Creek Church, location No. 40, Plate 1, a bed outcrops showing a thickness of 6 feet, overlaid by shaly sandstone. This bed is probably a low grade limonite on account of a high per cent. of silica.

Along the south side of the Whitesville sheet, the writer measured certain beds that should be noted here. In Iron Mountain one mile east of Washington School a bed has attracted considerable attention on J. E. McCormick's place. This bed is about 21 inches thick and contains considerable shale. The main ledge is about ten inches thick. About one mile southwest of Clear Run Church on the Hartford road, three beds are exposed in the first main hill south of Clear Run. The bottom bed is 20 inches thick, with an interval of 20 feet to the middle bed, which is about 5 feet thick covered by three feet of sandstone, which is in turn capped by the top bed showing a thickness of 30 inches.

The beds of limonite mentioned above are evidently interstratified with the sandstones and shales and are not concentrations at the surface. The beds here noted are all in the Lower Coal Measures.

Clay Deposits.

There are three general types of clay deposits in the region under discussion; these may be characterized as

follows: Fire-clay, clay shale, and residual or surface clay. It is not to be expected that any high-grade pottery clay or kaolin will be found associated with the rocks of this quadrangle. The clays, like the iron ores, are undeveloped.

At one time considerable fire-clay was shipped from Horton to P. Bannon, in Louisville, and to others. The clay was mined just at the edge of the town and one half mile south of town on the Thomson farm. The clay is four feet thick, of a semi-plastic character and of a gray color. Mr. A. V. Thomson, of the Kentucky Clothing Company in Louisville, who is interested in this clay, states that it is considered high grade by those who put it to practical use, but that the mining was abandoned on account of the crude methods of obtaining it, hauling on wagons to railroad and high freight rates to market. Clay has not been shipped from here for twelve or fourteen years.

Several of the coal beds have under-clays which will probably prove to be good fire-clays when practical tests are made.

Clay shale is common in the form of interstratified members of the Coal Measures. It is not a difficult matter to select beds of shale probably suitable for good brick and tile manufacture. Many such beds are free of nodules, etc., and easily accessible.

Residual clay in place, from the disintegration of rocks, and locally transported material to the valleys, furnish a good supply for common brick. Such clays have been used from time to time at various places for building brick in residences, the clay being obtained near at hand in each respective case.

Cement Materials.

It is probable that a number of the clay-shale beds and possibly some of the residual clays above mentioned will prove adapted to the manufacture of Portland cement when used in connection with suitable limestone. Apparently such limestone outcrops in quantity in the quadrangle along Rough river above Hartford. A 30-foot

section near the top of the Chester group, composed entirely of limestone, shows along the Madisonville, Hartford & Eastern railroad on the north edge of the quadrangle, Plate 2. Farther along the railroad lower beds of limestone and shale are exposed.

The manufacture of Portland cement is a profitable business when the raw materials are found in close proximity, are easily mined and ground, handy to fuel, and near to market. It seems probable that suitable conditions may be found by proper exploitation in this section of Kentucky. The Kentucky Geological Survey wishes to encourage tests on the cement materials and is lending its support by making analyses and studying the general conditions in the field.

Possibilities of Oil and Gas.

There are no oil or gas wells in the Hartford quadrangle. There have been a few attempts at deep drilling on a wild-cat plan but without success. In 1895 a well 1,400 feet deep was drilled by J. J. McHenry and associates about one mile northeast of Hartford near the Sulphur Springs road, location No. 41, Plate 1. Unfortunately no record was kept of this well in written form. Samples of the drillings were kept but the labels were lost before the State Geological Survey could obtain them. Salt water was encountered in this well at about four levels, some above and some below the 900-foot level. At the present time, salt water is standing to the top and slowly flowing over the casing; bubbles of gas are rising intermittently through the salt water in barely sufficient quantity to produce a flash when lighted. About one mile southwest of Hartford, location No. 42, Plate 1, a well 500 feet deep was put down in 1909 by M. W. Barnard; salt water was obtained here at 250 feet and is still slowly overflowing. Bubbles of gas rise in this well but not in sufficient quantity to flash when a lighted match is held near. This water is salty only to a slight degree but that of the well previously mentioned is strong. About two miles south of east of Beaver Dam, location No. 43, Plate 2, the Taylor salt well is also artesian and continues to flow a small stream of water, slightly salt.

The occurrence of salt water in these wells is interesting and suggests further prospecting. The writer suggests that wells be drilled to the north and northeast of Hartford in order to penetrate these salt water horizons and deeper strata at higher levels above tide. Such locations would be to the rise of the rocks where oil and gas, if present, would have accumulated. Fluids such as oil, fresh water and salt water segregate in accordance to their specific gravities, the lighter rising to the top when the three are in the same reservoir; gas, if present, would be confined above the oil; consequently oil and gas should be looked for at some point up the rise of the rocks from the salt wells. The rocks along the north side of the Hartford Quadrangle rise toward the Rough Creek Uplift, as mentioned under the subject "Structure." On the south side of the Whitesville Quadrangle, the rocks are folded into an anticline with the main Rough Creek fault zone on the north side. The south side of the anticline, so far as the writer observed, is unbroken but consists of small crumples on the flanks of the main fold. It is along the main flank that the writer recommends drilling. The vicinity of Concord Church on the east side of Rough river and the region just north of Beda on the west side of the river, both on the south edge of the Whitesville Quadrangle, the fields extending slightly into the Hartford Quadrangle, look especially favorable so far as structure is concerned.

Following is the substance of a report that was prepared for the West Kentucky Oil Company, by direction of the Director of the Survey, for the purpose of aiding that company to conduct its proposed prospecting for oil and gas in Ohio county in an intelligent manner:

Accumulations of oil and gas belong to that class of deposits which can not be located by the geologist from a study of the surface. This is especially true of an undeveloped region. He can, however, distinguish between favorable and unfavorable territory; he can classify certain districts as barren and be very positive of the waste

of time and money in prospecting them. It goes without saying, that if all the drilling for oil and gas had been based on intelligent geologic work, the percentage of gain would have been much greater than it has been. However, the public is coming more and more to recognize the importance of such work and the reports of Geological Surveys are coming to be more appreciated.

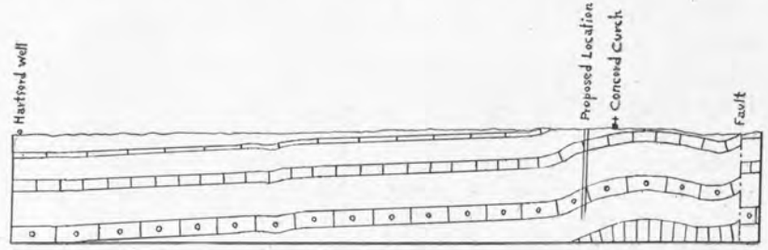
In locating territory for prospecting, the geologist should consider all available data and weigh it without prejudice; from all facts possibly obtainable at the surface, he draws reasonable deductions. The result is that he arrives at a point where he can go no further and must call on man's ingenuity in mechanics to determine, by drilling, what lies beneath the district he has selected. The one who drills must here take his chances. A large percentage of the odds against a random location have been removed, but the holes put down determine the facts which can be gotten in no other possible known way. The geologist stands ready to accept the results without surprise.

Having made the foregoing statements at the outset, the writer wishes to give a description of the conditions in a certain portion of Ohio county which have led him to consider that section sufficiently favorable to warrant prospecting for oil and gas. This the writer wishes to do in a direct manner with as few words and sketches as possible.

That oil and gas accumulate under such conditions as are found in Ohio county, has long been proven. Folding of the rocks in the earth's crust permits salt water, fresh water, oil and gas to segregate in accord with their specific gravities, the lightest rising to the higher portions of the fold. The particular type of folding to be mentioned here is that of an "anticline" or upward fold. It must be born in mind that the territory affected by this fold is not confined to a small locality but embraces several thousand acres. The fold is a part of the Rough Creek Uplift which crosses the county from east to west; this uplift is variable in character when considered along its entire length but from the vicinity of Sulphur Springs

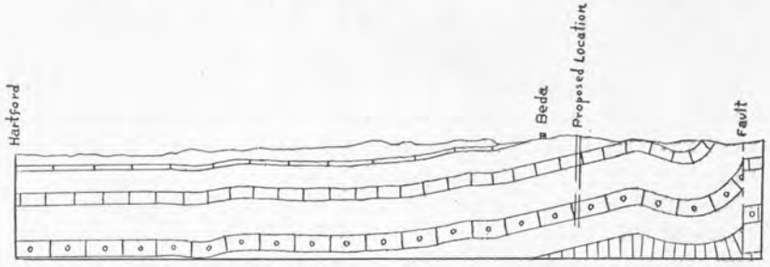
westward across Rough river and up Barnett's creek, it is an anticline faulted on the north side. The territory which is favorably folded and undisturbed by faulting is on the south side. The rocks on the south side slope southward away from the crest of the main anticlinal fold and it is along this belt that conditions are favorable. The surface rocks at each proposed location are very near the base of the Coal Measures.

The accompanying drawing will give an idea of the nature of the cross-section from Hartford northeastward by Concord Church. The cross-section is very



CROSS-SECTION FROM HARTFORD NORTHEASTWARD BY CONCORD CHURCH.

similar from Hartford northwestward by Beda. The region just northward from Beda is very much like that near Concord Church; the writer considers these two



CROSS-SECTION FROM HARTFORD NORTHWESTWARD BY BEDA.

localities favorably located in respect to the main structure. At several intermediate points the section is very

much the same, though there are slight differences in the details of the folding.

The absence of faulting on the south side of the anticline is noted in a study of the structure, though the reverses of dip due to erosion of minor folds and to weathering in the surface zone often present the appearances of faults. The absence of faulting is further proven by the artesian salt water in the deep well near Hartford. The head of this water must be up the rise of rocks toward the fold. This well is about 1,400 feet deep and was drilled by local parties searching for oil and gas, about ten years ago; salt water has been flowing over the casing since that date and intermittent bubbles of gas rise through the salt water in sufficient quantity to flash when ignited. The gas probably comes from a different stratum than the salt water; its presence further indicates the absence of faults and fractures in this region.

The north side of the main anticline is not favorable territory. The writer discouraged a plan in 1910 for drilling there and recommended the south side in the vicinity of Concord Church and Beda. The latter districts are those which it is now proposed to test with possibly an extension to the east and west. The north side is affected by the fault with a downthrow on that side. The presence of petroleum along the fractures of limestone in the fault suggests that there has been an escape here of the desired material; the oil in the fractures is likely that which remained from a flow to the surface along the break. On the south side, there has been no such chance of escape if the oil were ever present, and there is no evident reason why it should have been confined to one side only. The depth from which this oil may have come can not be determined; the throw of the fault is over 800 feet which means that the break goes down to considerable depths, possibly crossing all the sedimentary formations.

The three points which impress the writer in recommending a test of the Ohio county territory are the following:—(1). Suitable structural fold. (2). Absence of faulting and presence of salt water under pressure far-

ther down the dip. (3). Presence of petroleum on the north side of the fold along the fractures of the limestones in the Barnett's Creek fault.

In conclusion, the writer wishes to state that the conditions seem to warrant the drilling of at least one well to a depth of over 2,000 feet, in case it is barren to that depth. A complete and carefully tabulated well-record and samples of the drillings are of the utmost importance.

SOILS OF THE HARTFORD QUADRANGLE.

By S. C. Jones.

This quadrangle lies in the Western Coalfield within parallels 37° 15′ and 37° 30′ north latitude and meridian 86° 45′ and west longitude. This area lies almost wholly in Ohio county, including on the southeast a small portion of Butler county and on the southwest a small portion of Muhlenburg county.

Like all of the Western Coalfield, the geology is composed of alternating strata of sandstones, sandy shales, clays, slaty materials and a number of seams of coal of varying thickness and character. When these formations weather and the resulting materials intermingle soils of a rather uniform nature are formed.

The topography of the county included in this quadrangle is quite variable, the lowest altitude along the streams being 380 feet above sea level and the highest in the upland slightly more than 600 feet, giving a range in altitude of a difference of about 240 feet.

There are three phases of topography represented in the area 1st, the low flat bottom lands; 2d, the gently rolling or undulating upland; and 3d, the broken or dissected hilly area.

GENERAL DRAINAGE.

The southern half of the quadrangle is divided by the Green river and its tributaries, Lewis creek, Pond Run, Spur creek, Bull Run, Slaty creek, and Indian Camp creek, while the northern half is drained by Rough river and its tributaries, Muddy creek with its several prongs,

viz.: North Fork, Elmlick creek, Pigeon creek, Threelick Fork, Beaverdam creek, etc., and Mill Run, Morrison Run, Big Run, Walton creek and No creek.

SOIL TYPES.

Out of a total of 247 square miles of territory in the Hartford Quadrangle there are 172.19 square miles containing soil of residual origin and 74.81 square miles of transported origin. The residual soil occupies the upland and has been formed from the insoluble materials remaining in place after the disintegration of the overlying rocks, thus forming a cover over the deeper unaltered rocks, while the transported soil occupies the bottom land, having been carried in by the water of the small streams and rivers.

Classifying the soils of the residual and transported areas according to origin, topography and physical value, such as their content of sand, silt, clay, organic matter, color, etc., five types are recognized, three in the transported area and two in the residual. Named in order of area, these five types are as follows:

	Sq. mi.	Acres.	Per cent.
Yellow Silt Loam (Hilly),	135	86,400	54.65
Yellowish Gray Silt Loam (Bottom),	42.13	26,963	17.05
Yellow Silt Loam (Undulating),	37.19	23,801	15.05
Gray Silt Loam (River bottom),	20.25	12,960	8.19
Yellow Clay Loam (River bottom),	12.43	7,965	5.03

Yellow Silt Loam. (Hilly.)

More than half of the territory embraced in the Hartford quadrangle comes under this type, 86,400 acres or 54.65 per cent of the entire area. It occupies the dissected or hilly portion of the area which is interspersed with a number of bands or strips of bottom of a greater or lesser width extending along the streams. There is

an undulating area some three or four miles in width made up of the wide bottoms and undulating upland, extending across the quadrangle in a northwest and southeast direction, which divides the hilly region into practically two separate areas. The hills vary in height from 40 to 200 feet, the highest rising some 200 feet above the lowest bottom. They are usually not very large and present a somewhat serrated appearance, with usually narrow ridges.

In its origin the soil of this type is very closely related to the undulating yellow silt loam, the chief difference being that of topography which for cultivation separates them quite widely.

The surface soil is a yellowish or grayish silt loam with depth ranging from 6 to 8 inches. It is mellow and open and, unless tramped when wet, rarely breaks into clods and tills as nicely as a real sandy loam.

The subsoil is usually more claylike in its properties unless in places where the soil is shallow and the sandrock lies near the surface, in which case the subsoil becomes quite sandy; however, as a rule, at from 10 to 15 inches it has a bright yellow or reddish color with gray streaks and in places iron stains, where at from 15 to 30 inches it becomes decidedly more plastic because of a greater content of clay.

It is a well drained soil but at the same time possesses fairly good water holding properties. The surface soil is very open and porous, allows the rain water to enter easily, which is stored up in the more clayey subsoil; however, the capacity of the surface soil to hold moisture could be greatly increased by incorporating large quantities of vegetable matter which ordinarily is very much lacking.

The native timber found growing on this type consist of the different varieties of oak, beech, maple, hickory, sassafras, persimmon and in some places walnut. The valuable timber has practically all been cut off of the hills, and they are now covered with shrubs and a second growth of small trees.

The soils of this area are not so badly washed as are

the hills in some other sections of the Western Coalfield. They do not seem to have been cultivated so long before being turned back to a growth of shrubs and wild grasses. Only a comparatively small portion of this area is now under cultivation. Corn, wheat, tobacco and hay are the principal crops grown. Not nearly as much tobacco is grown as in the counties just west of Ohio county. The yield of corn varies from 15 to 20 bushels per acre, that of wheat from 10 to 15, and tobacco from 500 to 1,000 pounds. Hay is made from clover, cow peas, timothy and red top and yields on an average of about one ton per acre.

These hills should be kept in grass, timber and orchards. The land washes very badly when cultivated continuously. The Japanese clover is now the chief grass on these hills. It is inadequate for grazing because of not appearing until late in the spring and dying out with the early frost in the fall; and it withers and dies during even moderate drouths. With a grass able to resist drouths, that will make a sod on the silty or sandy soil, and that will grow early in the spring and late in the fall, the hills of the Western Coalfield could be made a profitable country for grazing. All kinds of fruits do well in the upland soils in this area and the location is such that there is seldom a year when fruit is a failure because of freezes and frost. The rough and badly eroded areas should be planted in a quick growth of timber such as the post-locust, which after twenty years would be yielding a handsome profit for the owner.

Yellow Silt Loam. (Undulating.)

The soil of this type includes 23,801 acres or 15.05 per cent of the total area. The largest areas border on the Muddy creek bottoms, the largest lying north of Beaverdam, embraced between Beaverdam and Muddy creeks; while the next in size lies just east of Hartford, north of Muddy creek. The remainder includes numerous small tracts or patches scattered in various places over the region.

This type is gently rolling and occupies the low upland areas, the gentle slopes and the broad ridges. Its origin is the same as that of the hilly area, though the soils are usually much deeper, the depth ranging from 12 to 20 feet to native rocks, while on the hill-sides rock is often found within two or three feet of the surface.

The surface soil is a yellowish or grayish silt loam, varying in depth from 6 to 10 or 12 inches. It is very loose and open and generally lies rolling enough to afford fairly good natural drainage, though the flat portions of the soil is rather gray, indicating of course the need of drainage.

The subsoil, because of less favorable drainage, is slightly more gray in color than that of the hills; otherwise, in their nature, the two types of soil (i. e., the undulating and the hilly) resemble each other rather closely. On the undulating soils maple, beech, and walnut are found more frequently than on the hills.

A much larger proportion of the "undulating" type is under cultivation than is true of the "hilly," but practically the same crops are grown with of course much better yields. Corn yields from 20 to 60 bushels per acre, wheat from 10 to 30 bushels, and tobacco from 800 to 1,400 pounds. Clover and grasses do well on fresh land but not so well on old land, unless well manured. This land is valued at from $25 to $50 or $60 per acre, while the hill land is valued at from $5 to $25, in both cases the price depending on location, state of cultivation, etc.

Yellowish Gray Silt Loam. (Bottom.)

This is a type that is quite common along all the small streams in the Western Coalfield. In this quadrangle there are 26,963 acres or 17.05 per cent. of the whole area. It lies along the small streams and has been derived chiefly from the immediate upland. There has been considerable material deposited in these bottoms since the hill land was cleared.

The surface soil varies from a gray to a yellowish silt loam, usually 8 inches or more in depth. In the low bottoms where water stands it is gray and crawfishy, where better drained it is yellowish in color, and is usually underlain by an incoherent silt of mealy texture; while the low wet areas are underlain by a more plastic material.

In the portion of these bottoms lying near the rivers the soil is somewhat modified by an intermingling of material from the back water, which renders the soil slightly more plastic and clayey in its nature. These places are so low that the overflow and back water render them practically worthless for cultivation. If it were not for the back water, deep ditching with a system of tile drainage would probably carry off the overflow and this land could no doubt be cultivated. Such an area extends from the mouth of Muddy creek almost up to Beaverdam. The land lying further back from the rivers in these bottoms can be reclaimed, unless during exceptionally rainy seasons, by a well planned system of ditching or tiling.

The native growth in these bottoms consist of black oak, red oak, sweet gum, sycamore and elm. Corn and hay are practically the only crops grown and because of such poor drainage the yields are low.

Gray Silt Loam. (River Bottom.)

This type is found in the bottoms of Green and Rough rivers and differs from the soil of the bottoms along the small streams, in that the materials comprising the soil are derived from a number of formations differing quite widely in their character.

There are of this type 12,960 acres, or 8.19 per cent. of the total area. The soil of the area varies somewhat in its physical nature, that near the river being usually more sandy and becoming more silty towards the upland. The silty strips along the river vary from a gray sandy loam to a brown sandy loam, ranging from 10 to 30 inches in depth. These patches are very productive and, because of lying from 5 to 8 feet higher than the bottom, away from the river the drainage is fairly good. Near the hills there is often found a thin deposit of bluff wash underlain with a gray silt material, although in places rather clayey in its nature. The bottom along Thoroughfare creek varies from a yellow to a gray silt loam while that along Bullrun and Slaty creek lies lower and is more clayey in its nature.

The land along Rough creek overflows more often than that along Green river. For the last five years crops have been drowned out almost every year. With a good system of drainage in the bottoms where there is no overflow this land can be made to produce maximum crops, and where there is an overflow the water after a freshet will be more rapidly removed and conditions made more favorable for growth of crops.

A growth of beech predominates to such an extent on this land that it is often known as "beech land." In the low places black and sweet gum are usually found.

Corn and hay are about the only crops grown, the yield depending on the amount of rainfall and drainage. Where the land is well drained and not injured by overflow water, corn will yield, when well cultivated, from 40 to 50 bushels per acre, while on poorly drained land practically no yield is obtained.

Yellow Clay Loam. (River Bottom).

This type, which has been deposited by overflow and by back-water, lies mainly along the larger streams. Of such soil there are 7,965 acres, or 5.03 per cent. of the total area.

The surface soil, which is a yellow clay loam, varies from 8 to 10 inches in depth. This type is very closely related to the gray silt loam (River bottom), and occupies neighboring areas, but differs from it in containing more clay.

Practically the same sorts of crops are grown on this soil as are grown on the gray silt loam, with no material difference in yields.

Note by C. J. N.—The soil work of the Survey is carried on in cooperation with the State Agricultural Experiment Station, the laboratory work being done by the latter organization. Samples for analysis, representing the several soil areas within the Hartford Quadrangle, were collected by Mr. Jones, and it is expected that the analyses will be received in time to be given in the general Soil Bulletin (now in course of preparation), in which the substance of the foregoing report by Mr. Jones, together with a soil map of the Quadrangle, will be included.